THE EXTINCT RODENTIA OF NORTH AMERICA.

BY PROFESSOR E. D. COPE.

(Continued from page 174.)

PLIOCENE AND POST-PLIOCENE RODENTIA.

CASTOROIDES Foster.

The only known species of this genus, the *C. ohioensis* Fost., is the largest of the order. It is found in the post-glacial deposits with the *Mastodon ohioticus*, in rather limited numbers.

Mr. J. A. Allen, of Cambridge, has studied the affinities of this genus, and states them as follows: "Castoroides presents a sin-

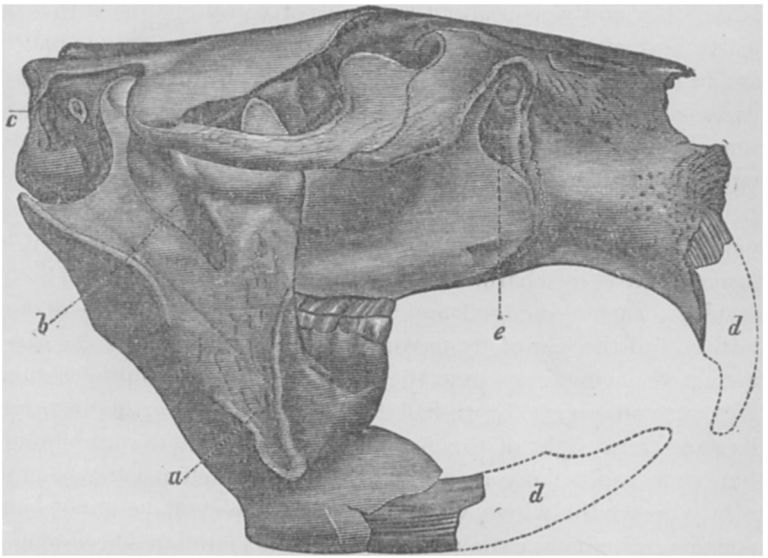

FIG. 22.—*Castoroides ohioensis* Fost., two-fifths natural size. *a*, Inferior limit of attachment of masseter muscle; *b*, Deep fossa below sigmoid notch of mandible; *c*, External auditory meatus; *d*, Superior and inferior incisors; *e*, Foramen infraorbitale. From Hall and Wyman.

gular combination of characters, allying it, on the one hand, to the beaver, and, on the other, to the chinchillas and Viscachas and also to the muskrat, but which at the same time separate it widely from either group."

"The molars differ strikingly in structure not only from those of Castor, but from those of all other rodents except the Chin-

chillidæ, a near resemblance being met with elsewhere only in the last molar of the Capybara. They consist of a series of laminæ of dentine completely inclosed by enamel, held together by a thin coating of cement. The circumference of the triturating surface of the tooth is thus devoid of the continuous plate of enamel that forms an uninterrupted border in the molar teeth of ordinary rodents, and is deeply serrated. The dentinal laminæ, with their

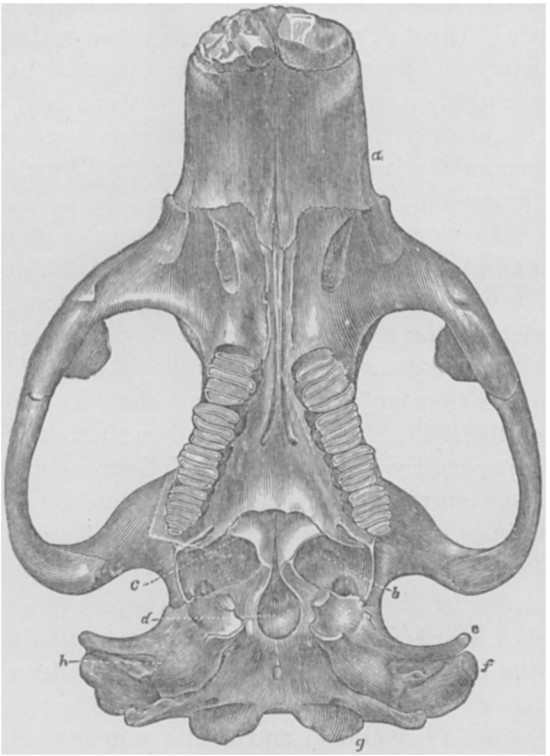

FIG. 23.—*Castoroides ohioensis* Fost., two fifths nat. size. *a*, Incisive foramen; *b*, Pterygoid fossa; *c*, Internal pterygoid plates; *d*, Fossa in basioccipital; *e*, External auditory meatus; *f*, Mastoid process; *g*, Condyles; *h*, Tympanic bulla. After Hall and Wyman.

inclosing plate of enamel, are three in number in all the molars, except the last upper and first lower, which have each four. When the teeth are exposed to disintegrating influences, the laminæ of dentine and enamel readily fall apart, as is the case in the molars of the Chinchillidæ, in the last molar of the Hydrochærus, and in the molars of the elephant. In structure the

molar teeth of Castoroides are strictly comparable with those of the Chinchillidæ, and with the posterior portion of the last molar of Hydrochærus, and thereby differ not only radically from that seen in Castor, but from that of all other rodents.

"The resemblance of Castoroides to Castor is mainly in the general outline of the skull, in its having an imperforate anteorbital wall, and in its presenting a similar curvature of the descending ramus of the lower jaw, the latter a character shared also by Fiber. The differences consist in the remarkable structure of the pterygoid processes, the double orifices of the posterior nares being entirely exceptional; in the flattened and relatively small cranium, and in the compound nature of the molar teeth. These differences ally it on the one hand to the Chinchillas, from which it differs mainly through those points in which it resembles Castor. In view of these wide differences from its nearest well-known allies, it seems to constitute the type of a distinct and hitherto unrecognized family. To the same group are, however, probably referable the genus Amblyrhiza, described by Professor Cope, from the bone caverns of Anguilla island, West Indies. These forms are thus far known only from the detached teeth and fragments of the limbs. The molars as described and figured by Professor Cope, greatly resemble those of Castoroides, having in fact the same structure, differing mainly in being somewhat smaller, and in possessing a greater number of laminæ. (There are also other differences, see below under Amblyrhiza.)

"The *Castoroides ohioensis* was of about the size of a full-grown common black bear (*Ursus americanus*), hence somewhat exceeding in size the Capybara, the largest of existing rodents. A cast of a skull has a length of over twelve inches. The species being known only from a few cranial and dental remains, it is impossible to say much respecting its general form or probable habits. It may have been aquatic like the beaver; but of this there is no evidence. The form of the occipital condyles and the surfaces for the attachment of the cranial muscles show that it probably differed greatly in habits from the beaver."

The sculpture of the incisor teeth of this species is elegant, and distinguishes it readily from all other Rodentia.

SCIURIDÆ.

Squirrels were probably abundant during the latest Tertiary

periods in the United States. I have described a true squirrel, *Sciurus panolius*, and a chipmunk, *Tamias lævidens*, from Virginian cave deposits, and have found indisputable remains of the ground marmot, *Arctomys monax*, associated with them. In the Port Kennedy bone cave in Pennsylvania, Mr. Wheatley found *Sciurus calycinus* Cope, associated with Megalonyx, etc.

Remains of the beaver are common in the latest Tertiary beds.

MURIDÆ.

Jaws undistinguishable from those of the jumping mouse, *Meriones hudsonius*, were found in the Port Kennedy bone cave. A large wood-rat, *Neotoma magister*, was found by Professor Baird in the Carlisle, Pa., bone cave. The meadow-mice (Arvicola), left numerous remains in the Port Kennedy cave, which represent no less than six species.[1] Four of these are related to the

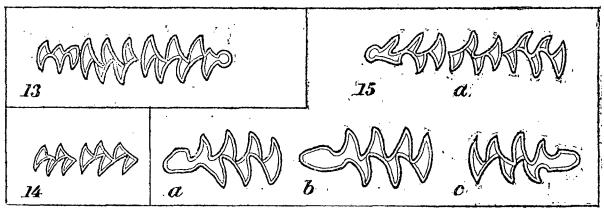

FIG. 24.—Diagrams of molar teeth of Arvicola, from the Port Kennedy bone cave, Pennsylvania, enlarged. No. 13, *A. speothen* Cope; No. 14, *A. tetradelta* Cope; No. 15, *A. didelta* Cope. From Proc. Am. Philos. Soc. 1870.

recent smaller meadow-mouse, *Arvicola pinetorum;* while two, the *A. speothen* and *A. hiatidens* Cope, represent special divisions of the genus. These I have called Isodelta and Anaptogonia respectively. The *A. hiatidens* is one of the largest species of the genus, and the columns of the first inferior molar are more numerous than in the species found with it. The inflected angles between the columns do not touch the sides of the opposite columns as in most species of the genus. Arvicolas also occur in the Pliocene of Fossil lake, Oregon.

SACCOMYIDÆ.

I found an almost perfect skeleton of a "gopher" in the won-

[1] See Proceedings American Philosophical Society, 1871, p. 87.

derful bone deposit known as "fossil lake" in the Oregon desert. I cannot distinguish it from that of the *Thomomys bulbivorus*, now living on the borders of that region.

Professor B. F. Mudge discovered the skull of a large species of the genus Geomys in the sands of the Blue river, Kansas, which I cannot distinguish from a living form.

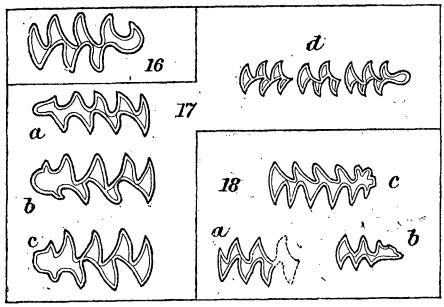

FIG. 25.—Diagrams of molars of Arvicolæ, from the bone cave at Port Kennedy, Penna., enlarged. No. 16, *A. involuta* Cope; No. 17, *A. sigmodus* Cope; No. 18 *A. hiatidens* Cope. From Proceed. Am. Philos. Soc. 1870.

AMBLYRHIZA Cope.

This remarkable genus of rodents was first detected by me as found in the West Indian island of Anguilla. I have since seen molars of a species of the genus in a collection in Charleston, South Carolina, showing that it extended its range to the continent, and must be included in our Pliocene fauna.

In the year 1868 a quantity of cave earth, limestone fragments and bone breccia were brought to the port of Philadelphia from a cave in the small Antillean island of Anguilla, which belongs to Denmark. Through the attention of Mr. Waters I learned of the existence of fossil bones in the cargo, and proceeded to examine them. Remains of long bones lying irregularly in a rather hard but cavernous red cave deposit of limestone, were found mingled with fragments of lighter limestone from the walls of the cave in irregular masses, the whole being penetrated and mixed with a yellow stalagmitic deposit of arragonite.

From a block of the breccia I dressed three molar teeth, two partially complete, and two much broken incisors, fragments of maxillary and pelvic bones, shafts of various long bones, and the

distal extremity of a femur with a patella. These were the first evidences of the existence of the large rodent *Amblyrhiza inundata*, which was described in the Proceedings of the American Philosophical Society for 1868. Other bones were found in other breccia masses, which I could not clearly refer to any other animal. With them occurred a shell of *Turbo pica*.

Having learned that Dr. E. van Rigjersma, colonial physician of the Danish island of Saint Martins, was interested in the natural sciences, I wrote, asking him to make an examination of the deposit in question, and to secure, if possible, all fossils discovered in excavating it. He accordingly very kindly went to Anguilla and was rewarded by the possession of numerous additional teeth and bones of Amblyrhiza. Subsequent visits added two species of this genus, together with the bones of a species of ruminant of uncertain genus; bones of a probable rodent of smaller size of two species of birds, of a lizard, and a shell chisel of human manufacture.

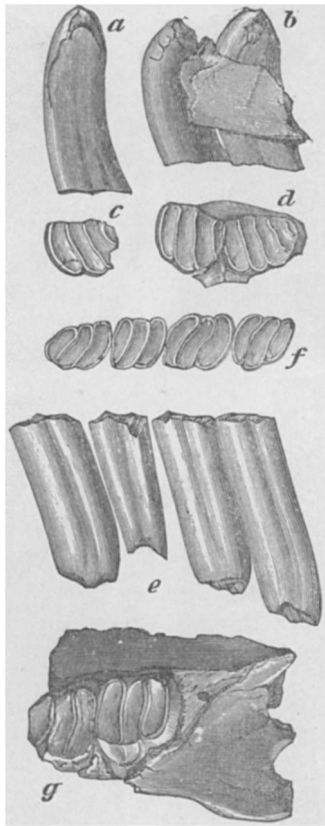

FIG. 26. — Teeth of Amblyrhiza, from Anguilla, two-thirds natural size. Original. Figs. *a–b*, *Amblyrhiza inundata* Cope, superior molars, lateral view; *c–d*, from below. Fig. *e*, inferior molars, lateral view; *f*, from above. Fig. *g*, posterior part of mandible of *A. latidens* Cope, showing molar and lateral coronoid process.

The three species are *A. inundata*,[1] *A. quadrans* and *A. latidens* Cope. The first named is the smallest species, and the teeth from Charleston are perhaps referable to it. All the species agree in presenting the following characters:

The premaxillary bones and the symphysis mandibuli are much produced and narrowed, and were probably enclosed in fur-bearing integument, as in the existing Chinchillas. The

[1] The *Loxomylus longidens* was probably based on inferior molars of this or of a nearly allied species.

mandibular rami are completely coössified. They are united at their lower borders posterior to the divergence of their dental ridges, by the expansion of the stout rib of their inner face which encloses the incisive alveolus.

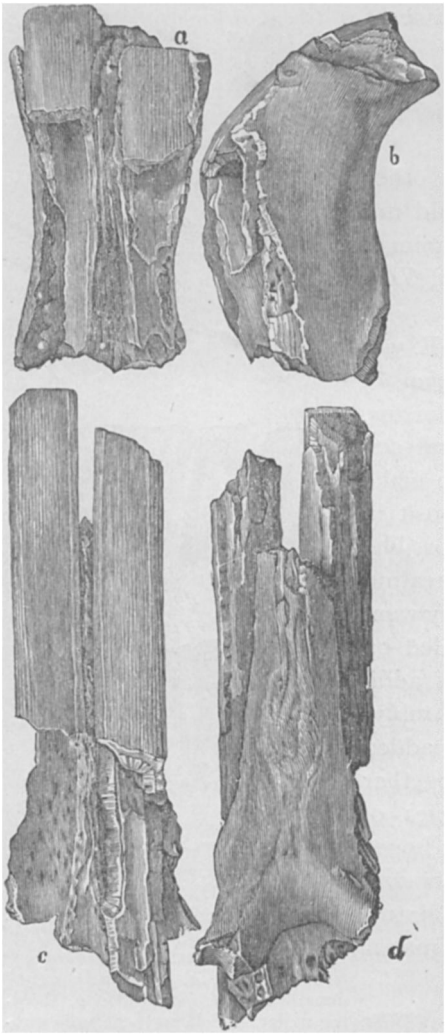

FIG. 27.—Jaws of *Amblyrhiza latidens* Cope, two-thirds nat. size, from Anguilla, W. I. Original. Fig. *a*, superior incisors from above; *b*, lateral view; Fig. *c*, inferior incisors from below; *d*, do. from above, with symphysis.

The dental formula is I. $\frac{1}{1}$; C. $\frac{0}{0}$; M. $\frac{4}{4}$. The incisors have a moderately thick enamel layer which is wrapped round the external angle a short distance. Their sculpture is not deeply cut. The molars are composed of vertical columns of dentine enclosed in and separated by laminæ of enamel. The columns are more or less transverse, and are neither confluent nor divided in any of the teeth. They number four in the superior teeth, excepting in the last molar where there are five. The entire tooth is enclosed in a thin layer of cement. The superior molars are curved bow-shaped, the convexity being directed forwards at the middle of their length. The enamel plates are then directed backwards on the grinding faces. The extremities of the roots are simple and contracted to an obtuse termination. The inferior molars differ in their form, being straight and directed obliquely forwards in the jaw. From this it results that their triturating surfaces are oblique to the axis of the teeth, while those of the superior mo-

lars are transverse to the axis of the middle portion of the shaft. There are but three columns in all of the inferior molars.

The only caudal vertebra preserved is short and wide, has short diapophyses, and no facets for chevron bones. As there is no trace of neurapophyses on the centrum, I infer that the tail is short.

The fore-limb is of smaller proportions than the posterior one.

The humeral condyles have the ulnar and radial portions about equal, and the intertrochlear ridge is represented by an obscure angle. Both ulna and radius are slender.

The femur has several marked peculiarities. One of these is the great development of the great trochanter, which is really an undiminished continuation of the shaft for some distance beyond the head. The head is relatively small.

FIG. 28. — Proximal portion of femur of *Amblyrhiza latidens*, two-thirds natural size. From Anguilla, W. I. Original.

The distal extremity of the tibia is expanded inwards. The astragalar facets are oblique; the external is larger than the internal, and they are well separated by an obtuse ridge. There are two processes on the internal border, which are separated by a deep tendinous groove, which is, in most of the specimens, bridged over by a lamina connecting the processes. The posterior of the two processes is the most elongate. It corresponds to a process of the astragalus which extends backwards and inwards from the internal trochlear face. When extension of the foot is attempted, the processes come into contact, and prevent further movement. The amount of extension from the horizontal which this arrangement permits is 45°. When the foot is extended the processes constitute a support to the weight of the animal in addition to that furnished by the usual astragalar facets.

The metatarsal bones are distinct from each other and are quite short. There were certainly four toes, and the hallux may have been rudimentary. The foot was clearly plantigrade. Whether the digits terminate in hoofs or claws, is unknown.

The lack of tibial crest indicates that the knee was not constantly maintained in a flexed position. The immense trochanter indi-

cates great power of extension of the femur, but whether this extension was effective in running or kicking is uncertain. The absence of tibial crest, and the shortness of the foot militate against the supposition that these animals possessed powers of leaping, and their swimming powers would be impaired by the same structural characters. These characters of the posterior limb in Amblyrhiza are very peculiar, and are no doubt connected with some peculiarity of habits which we have yet to ascertain.

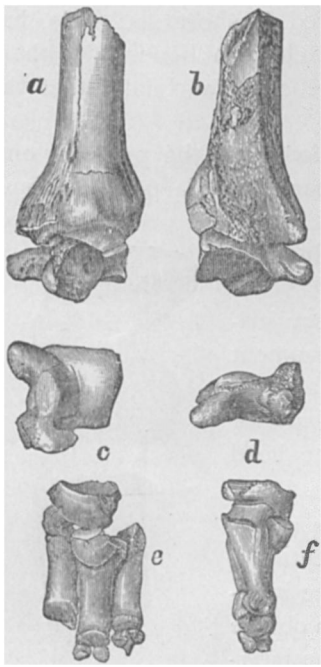

FIG. 29.—Posterior foot of Amblyrhiza, two thirds nat. size. Fig. *a*, tibio-tarsal articulation of *A. latidens* from front; *b*, from behind; *c*, astragalus of do, from above; *d*, from external side; *e*, second row of tarsal bones with three metatarsals of *A. inundata* from front; *f*, from inner side. From Anguilla. Original.

This genus clearly enters Professor Brandt's division of the Rodentia, which he terms the Hystricomorpha. The evidence is seen primarily in the free fibula and in the development of the angular portion of the mandible on the external side of the incisive alveoli; the small coronoid process and the generic characters add to the weight of the evidence. Mr. E. R. Alston has recently published a very valuable resumé of the characters of the subdivisions, including the genera of the Rodentia. He divides the Hystricomorpha into numerous families, some of which, at least, appear to the writer to rest on rather slender bases. In the comparison with Amblyrhiza, the Hystricidæ and Dasyproctidæ may be dismissed, from the fact that their molars are not divided transversely by laminæ of enamel. The comparison is with the Chinchillidæ and Caviidæ. The molar dentition is that of the former family, but the absence of a masseteric ridge separates it from the genera arranged by Mr. Alston under the Caviidæ, although I cannot perceive that such a character should define a family group. The incisors of both these groups are called by Mr. Alston "short." I have shown those of Ambly-

rhiza to be very long, as in the Dasyproctidæ; nevertheless their transverse section and sculpture are much as in the genus Lagidium. The affinities of this form are, then, near to types now existing on the South American continent, but it presents characters which show that it cannot be referred to any existing genus.

The *Amblyrhiza inundata* may be described as frequently supporting itself on its hinder legs, with the entire hinder foot applied to the ground, and its smaller fore-legs hanging by its side. Its general bulk could not have been less than that of a doe Virginian deer. What its habits could have been, cannot readily be inferred, but its food was doubtless of the general vegetable character of other members of the order. The *A. latidens* must have been larger than the male Virginian deer.

HYDROCHŒRUS Briss.

The only existing species of this genus, the Capybara, is the largest of Rodentia living, and is confined to South America. Leidy has described a species from the Ashley river deposits near Charleston, South Carolina, under the name of *H. æsopi.* Its teeth, the only portions known, are similar to those of the Capybara, but according to Leidy, the inferior incisor tooth is more strongly ridged than in the living species.

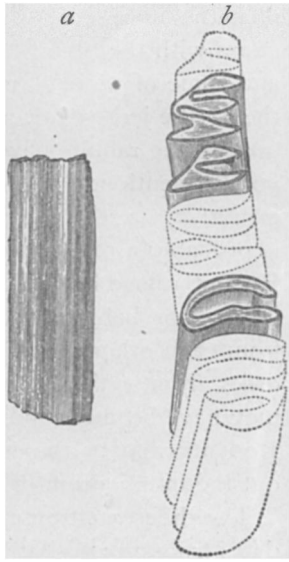

FIG. 30.—Teeth of *Hydrochœrus æsopi* Leidy, nat. size. From Charleston, S. C. After Leidy. *a*, fragment of superior incisor; *b*, the shaded portions represent parts of inferior molars found.

ERITHIZON F. Cuv.

The existing American porcupine was represented in the Megalonyx beds by a species, the *E. cloacinum* Cope, of which a single tooth was found in the Port Kennedy bone cave.

LAGOMORPHA.

A rabbit-like animal, probably of the genus Lagomys, was found in the Port Kennedy bone cave. It is rather larger than the *Lagomys princeps* of the Sierra Nevada. It is of interest, because no species now inhabits the eastern part of the American continent. I have called it *Lagomys palatinus.*

The Development of the Rodentia.

The Rodentia, like other divisions of Mammalia, present a succession of changes of structure in time, in the feet and in the teeth. The earliest known forms, as above pointed out, are the allies of the squirrels, members of the sub-order Sciuromorpha. These have the most generalized foot structure because: first, the trochlear structures of the humerus and tibia are not at all or but little developed; second, because they have five digits on the feet, and are plantigrade; and third, because the fibula is not coössified with the tibia. They are similarly primitive in the forms of the teeth, because they are rarely prismatic, and nearly always have long roots and short crowns. The cavy division, or sub-order Hystricomorpha, must claim the next place, but many of its members show a decided advance in having a limited number of toes, and prismatic dentition. In the third sub-order, Myomorpha, the mice, etc., we first meet with the coössification of the fibula with the tibia. A good many genera have prismatic teeth, and some of them a restricted number of digits; and a few of them (the jerboas) even metatarsal bones coössified into a cannon bone. The rabbits have the most specialized characters in all the points mentioned, but they add another character which is most primitive, viz., the presence of four superior incisor teeth. This is probably a remnant of the primitive group from which all the Rodentia have been derived. By the law of homologous groups it is not probable that the divisions of Rodentia were descended from each other, but from corresponding groups of the primary order from which they were derived as a whole. This division may have been the sub-order Tillodonta of the Eocenes, or the Rodentia may be the descendants of the Marsupialia with or without the intervention of that group.

The differentiation of the sub-orders of the Rodentia evidently dates from a period at least as early as the lowest Miocene. It is an important fact that the Lower Eocene (Wasatch epoch) has as yet produced nothing but the lowest type (Sciuromorpha). It is also true that the Puerco Eocene epoch has, in sixty species of Mammalia, disclosed no Rodentia at all, while Tillodonta and Tæniodonta are abundant.

The Myomorpha first appear in the White River beds (Oligocene), but none with prismatic teeth occur below the John Day epoch. The Lagomorpha, on the other hand, present us with

almost all their special characters at once, in the White river. The Hystricomorpha, whose home is in South America, are unknown in North America below the Loup Fork or highest Miocene, where Leidy identified a true porcupine, *Hystrix venustus.*

Many of the extinct genera stand in evident genetic connection with existing forms. The Miocene Castors doubtless include the ancestor of the modern beaver. The Ischyromys is a primitive type of the Sciuridæ, and Gymnoptychus connects it directly with the existing forms by the character of its molar teeth. Eumys is the primitive form of Hesperomys, as Paciculus is of Sigmodon. Entoptychus and Pleurolicus are the near ancestors of the Geomyidæ of the Pliocene and present periods. Palæolagus, Panolax and Lepus form a direct genetic line. The ancient genera all differ from their modern representatives in the same way; that is, in the greater constriction of the skull just posterior to the orbits and accompanying absence of postorbital processes. This relation may be displayed in tabular form, as follows:

Skull wider behind orbits.		Skull narrower behind orbits.	
Postorbital processes.	No postorbital processes.	Postorbital processes.	No postorbital processes.
.....	Castor fiber.	.....	Castor peninsulatus.
Sciurus.	.....	.....	Ischyromys.
.....	Hesperomys.	.....	Eumys.
Lepus.	.....	.....	Paleolagus.

None of the species of this fauna are of larger size than their modern representatives. In the cases of the beaver, squirrels and rabbits, the ancient species are the smaller.[1]

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HETEROGENETIC DEVELOPMENT IN DIAPTOMUS.

BY C. L. HERRICK.

IN a paper in the Report of the Geological and Natural History Survey of Minnesota, the writer suggested that this genus is unusually affected by changes in the environment, and an example is given in the case of *D. castor.* The form called *giganteus* was shown to be probably an enlarged variety of the above. In a paper in the NATURALIST this matter was expanded and an attempt made to parallelize the two forms with the two

[1] For these conclusions see Bulletin U. S. Geolog. Survey Terrs., VI, 1881, 362–3.